THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

The booming, get-rich-in-a-hurry era in the uranium industry is well in the hectic past. Big business organizations have moved into the field and operations have settled down to a pattern of orderly mining, milling, and prospecting. Current production is valued around $500,000,000 a year, with the main activity centered on the Colorado Plateau, with major production coming from New Mexico, Utah, Colorado, and Wyoming.

This issue of THE EXPLOSIVES ENGINEER is devoted exclusively to the presentation of a comprehensive article on uranium by Lewis Nordyke. The article is highlighted by reproductions of eight original drawings by Louis Heinzman, showing an artist's conception of scenes and scenery in the Indian Country so rich in uranium deposits.

The article briefly describes operating procedures at several well-known mines: LaSalle Mine, near Uravan, Colorado; Mineral Joe Mine on Monogram Mesa, near Naturita, Colorado; Cord and Radon Mines in the Big Indian; Charles Steen's Utex Exploration Company, also in the Big Indian; and Delta Mine (Vernon Pick) on Muddy River, Utah.

Fast becoming one of uranium's major operators in New Mexico and Arizona is Kerr-McGee Oil Industries of Oklahoma City, Oklahoma. Long recognized as a progressive, growing organization in the petroleum industry, Kerr-McGee branched into uranium in 1952 with the purchase of Navajo Uranium Company. It owns and operates mines in the Lukachukai Mountains at Cove, Arizona, carries on a tremendous development project in an orebody at Ambrosia Lake, north of Grants, New Mexico, and processes ore in a $4,000,000 mill near Shiprock, New Mexico. Recently, Kerr-McGee joined with two other companies to mine and mill ore at Ambrosia Lake.

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

The mill at Shiprock, which operates around the clock, is the seventh erected on the Plateau. Beginning operations on November 1, 1954, the mill has been a pioneer in methods used to process the uranium ore. Originally, the Shiprock mill used the acid cure method; later, a direct leaching process was adopted. In July of this year, the plant was being equipped for the third method, the solvent-extraction process. Unexpected developments in the new industry and advances in metallurgy prompted the changes in the processing methods at Shiprock.

Kerr-McGee's new mill at Ambrosia Lake will be six times as large as the Shiprock plant. Unlike the operations at Shiprock, it will use a carbonate leach process. The orebody at Ambrosia Lake, a carbonaceous sandstone mineral, is tremendous; the reserve is so great that it remains classified information.

In the article beginning on page 135, Mr. Nordyke describes drilling and blasting procedures at some of the mines, outlines the processing methods used by Kerr-McGee, and pays tribute to the cooperation of the Navajo Indians who inhabit this wildly beautiful country.

* * *

Reproductions of Louis Heinzman's original drawings begin on page 141. Mr. Heinzman is an outstanding artist of the American Western scene. The reproductions of the drawings are prefaced by an essay by Ashworth Burslem. Please turn to page 141.

* * *

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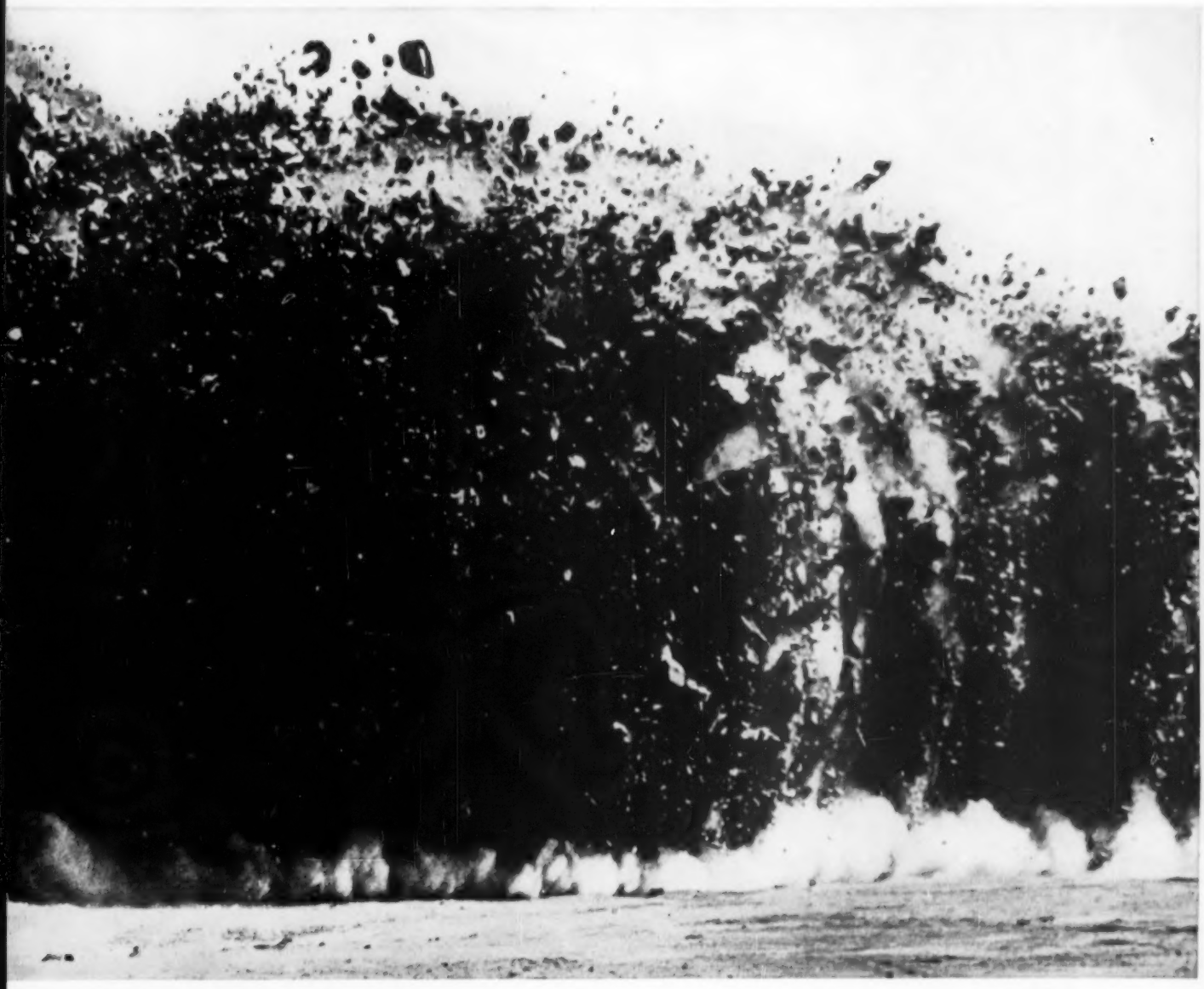

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2856-6

L. RUSSELL KELCE

L. Russell Kelce

PRESIDENT AND CHIEF EXECUTIVE OFFICER
PEABODY COAL COMPANY

A Biography

THE career of L. Russell Kelce, president and chief executive officer of Peabody Coal Company, the number two coal producer, exemplifies constructive leadership in establishing great enterprises, and outstanding success in the administration of large organizations in basic industries.

Russ, as he is known to his friends and associates, was born in Pittsburg, Kansas, on August 5, 1897, the son of David and Etta Kelce. His father owned and operated a small coal mine in Pittsburg.

When Russ was fifteen and a sophomore in high school, his formal education was suddenly interrupted by a near-fatal accident to his father in the mine. The accident broke his father's back, a foot, and several ribs; wrecked the mine; and destroyed his dream of higher education for his children. Russ left school and went to work immediately, for now he was the sole support of a family of seven. His first job was handling mine cars at the bottom of the shaft in Mine No. 14 of Western Coal and Mining Company.

The young miner's ambition was to be a superintendent. Russ realized that ambition at the age of nineteen when he was made superintendent of a mine owned by Ellsworth-Klaner Coal Company.

With the entrance of the United States in World War I, Russ joined the Army. Upon discharge from the service as a sergeant (Infantry), at the age of twenty-two, he migrated to Tulsa, Oklahoma, and raised sufficient capital to lease a strip mine at nearby Dawson. The mine, named Leavell Coal Company, was so successful that Russ' initial indebtedness was paid off many months before maturity.

In 1921, when Russell Kelce was establishing himself as owner and operator of Leavell Coal Company, another man — Grant Stauffer — was attaining prominence as president of Sinclair Coal Company, an organization that sold coal but did no mining. Kelce and Stauffer entered into an agreement which stipulated that the Sinclair company would sell all the coal produced at the Leavell mine.

The combination of an operating man and a sales executive was a success from the beginning and, later, the two men entered into a partnership agreement. From time to time, they purchased new mines and formed companies to operate them in Kansas, Iowa, Missouri, Oklahoma, Illinois, Kentucky, Indiana, and Alabama.

In 1931, Mr. Kelce was named vice president in charge of operations of Sinclair Coal Company, with headquarters in Kansas City. Two years later he succeeded to the presidency. On July 12, 1955, Peabody Coal Company acquired the Sinclair interests and L. Russell Kelce was named president and chief executive officer, the position he holds today.

During the calendar year 1955, the two companies, Peabody and Sinclair, produced and sold about 19 million tons of coal. Approximately 11½ million tons were produced by the strip mining method and 7½ million tons came from underground mines.

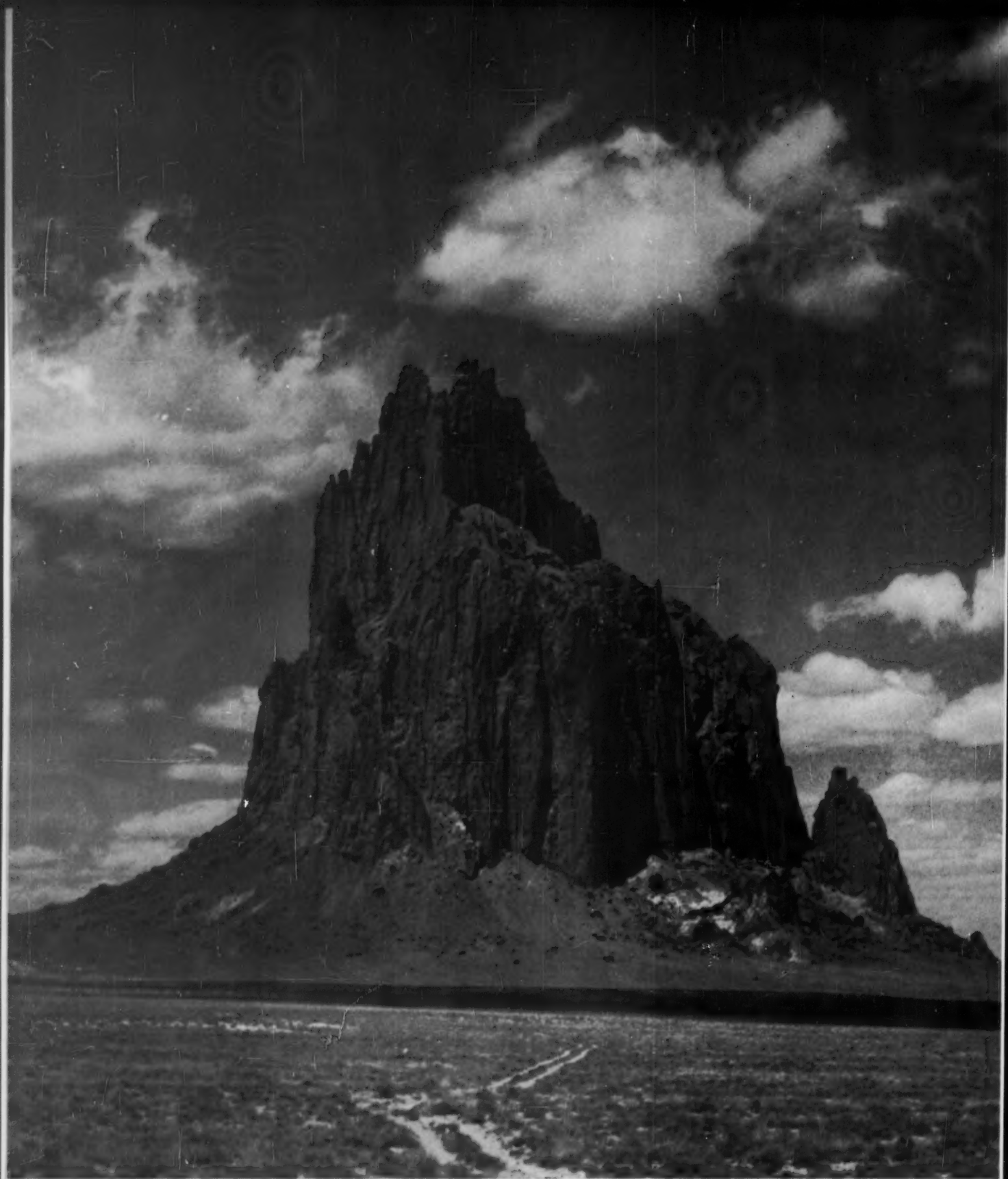
Coal has always been in the forefront of Mr. Kelce's thoughts and interests: he is a director of Southern Coal Company; chairman of the board of Chicago, Great Western Railroad, which derives a large part of its revenue from the transportation of coal; head of the Rail to Water Transfer Corporation of Chicago, operators of a huge belt that moves coal from railroad yards to ships in Lake Michigan; director of Locomotive Development Company, which hopes to market a locomotive that operates on the principle of a diesel but powered by coal.

Russ Kelce is also very much interested in land conservation: his project, Sinclair Farms, Inc., has converted more than 40,000 acres of worked-out strip mine properties into productive forests and grazing pastures. Besides being a member of the National Coal Association's executive committee, he is chairman of its land use committee. Currently, he is working with several states to transform abandoned strip pits into game preserves. His other business interests include livestock, farm and heavy-construction machinery, and oil. In all, he has a hand in some thirty enterprises.

His clubs include the Kansas City, Saddle & Sirloin, River, and Mission Hills Country in Kansas City; the Chicago and Union League in Chicago; and the Bohemian in San Francisco.

L. Russell Kelce married Gladys A. St. John on September 22, 1920, in Pittsburg, Kansas. They have one son, Robert D., a graduate of Kansas State College. The family home is Merryvale Farm, a 1,000-acre showplace at Grandview, Missouri. At Rainy Lake in Canada, Mr. Kelce owns an island complete with lodge and guest house.

The greater part of Russ Kelce's waking hours is devoted to the ramifications of his many and varied business interests. But, being a friendly man who enjoys the companionship of a wide circle of friends and out-of-doors sports, he manages to find time to relax and fish at Rainy Lake, hunt deer and moose in Canadian woods, pheasant and quail in Missouri and the Dakotas, and ducks on the Gulf of Mexico.



This isolated mass of rock looming 1,750 ft. above the desert in northwestern New Mexico is known as Shiprock.

URANIUM

With current production valued at $500,000,000 a year, the mining and milling of uranium in some Western States is big business

LEWIS NORDYKE*

It's a story they tell at the Kerr-McGee mining camp in the foothills of the Lukachukai Mountains at Cove, Arizona. A wrinkled Navajo has figured out how the meek, because of uranium, stands a chance to inherit the earth, which for him and his Indian brothers is the desolate and remote reservation that unfolds endlessly over a swath of tortuous terrain in New Mexico and Arizona.

The old Indian observed the blasting of uranium ore by the mining division of Kerr-McGee Oil Industries, Inc., Climax Uranium Company, and others in the Lukachukais, and the workings of the mill just outside Shiprock, New Mexico, and then he philosophized:

"The Navajos are helping to dig uranium for bombs that will destroy all the races of the earth except the Navajo. They won't bomb our reservation because it's no good to them. And, they can never drop enough bombs to kill all the Navajos in their hogans scattered in the hills. So, when all other races are gone, the Navajo will still be here to dwell in peace and hunt with bow and arrow."

The Indians seem awed by what is happening on their reservation – the roaring and rooting of the dozers on towering mountainsides, the groaning of trucks, the whirring of the mill, and the sounds of the "thunder sticks" as they break the ore deep in the drifts, the rooms, and the stopes.

But the red men are scarcely more perplexed by the amazing uranium business than the mining company executives, the engineers, the geologists, and the metallurgists. With most of the booming, get-rich-in-a-hurry era well in the hectic past, the uranium industry in the United States is settling down to a pattern of orderly mining, milling, and prospecting.

*2809 Lipscomb Street
Amarillo, Texas

AEC Program

The answers to some of the questions that have been bothering the producers and investors have been at least postponed, providing a breather. The Atomic Energy Commission, the only buyer of the end product of the mills, had set up a program which was due to end in 1962. Recently, the program was extended to 1966. The significance of this action is apparent in the remark of one mine superintendent in the Big Indian District some 40 miles out of Moab, Utah. When asked how long the orebody in his mine would last, he replied:

"At first, we had everything geared to get it out by 1962. Now we don't have to rush so fast; we have until 1966 to get it out."

With the Government the only buyer and the military stockpile the sole pressing need, no one knows what may happen to uranium after the end

ROOTING OUT A ROADWAY: This bulldozer is rooting out an eyebrow roadway in the Lukachukais. Road building in the hills and canyons represents a tremendous job of drilling, blasting, and bulldozing.

of the present program in 1966. Will there be commercial demand? What about uranium as a source of fuel and power for generating electricity? Are there home or medical uses? Just how much of the stuff does the military need? These are bothersome questions that mining men can toss around. But, the questions do not have to be answered until the approach of 1966.

Meanwhile, mining and milling go on and stockpiles grow, with most of the work in the hands of competent companies. Many of the quickly organized stock outfits are as out of business as a caving stope with the pillars pulled. Moreover, the organization of new companies for exploring or mining in 1956 will be less than one-half the number formed in 1955. These percentages hold true throughout the main production area, especially on the wide and wild Plateau of the Colorado River.

Production on the Increase

Yet overall production is climbing. Back in 1948, when the AEC was created to direct the stockpiling of atomic material, only 70,000 tons of uranium ore were mined in the United States. Late in June, 1956, AEC announced the previously secret figures that production had increased to more than 3,000,000 tons of ore annually, and this total stands a good chance of being doubled. At the time of the release of the production figures, Jesse C. Johnson, raw materials chief of AEC, said that the United States has known uranium ore reserves of 30,000,000 tons and potential reserves in the present production areas of another 30,000,000 tons. Despite large developments in South Africa and Canada, this country is still the big producer. Mr. Johnson also commented that if production develops as planned the free world will eventually turn out 30,000 tons of U_3O_8 each year.

At the same time, J. J. McMullen, chief of ship construction and repair for the U. S. Maritime Commission, answered one of the questions that have been wrinkling the brows of producers when he reported that an atomic-powered oil tanker was on the drawing board. Using essentially the same type of reactor that now powers the submarine Nautilus, the new tanker could transport oil for a full year on about 700 lb. of uranium. He suggested that it was doubtful whether there would be any more capital ships built that were not atomic-powered.

By the first of July, 1956, some 14 mills, with various methods of recovering yellow cake, were in operation or under construction. Almost as many more were in the planning stage.

All this has happened to uranium in a hurry – within the past few years. It is big business now, running around $500,000,000 a year. The main activity has centered on the Colorado Plateau, with major production coming from New Mexico, Utah, Colorado, and Wyoming. About 70 per cent of current production has come from the Big Indian-Lisbon Valley of Utah, the Laguna Indian Reservation of New Mexico (spearheaded by Anaconda's Jack Pile Mine), and the Grants, New Mexico, area. Likewise, the big percentage of known reserves lies in these same areas, with Ambrosia Lake promising to take the lead. Also, there's brighter hope than a hungry prospector's dream for some new areas; for example, northern Michigan and Wisconsin, scattered places in Texas, Idaho, Montana, California, the Tonapah region of southern Nevada, and the Spokane Indian Reservation in northeast Washington.

There are around 1,000 operating mines, big and little and of every sort – open pit, drift-in, incline, and vertical shaft. One mine in Colorado was located on such a high and rough mountain top that it was not economically feasible to blast and doze out an access road, and the ore was lifted downhill by helicopter and dumped into trucks. It is difficult to find two mines that operate in the same way; each operation has its own peculiar problem. There are heavy limes, which give the acid-leach mills a fit. Some mines have to haul water, while others have too much of it. In almost any of the mines, the orebody is apt to pinch out, widen, turn, dip, or rise. Some of the formations are hard, some soft, some just plain tough. Whatever the mining or metallurgy problem, the engineers have solved it, mine by mine and mill by mill.

LaSalle Mine

One of the efficient operations is the LaSalle Mine near Uravan, Colorado. Owned by the LaSalle Mining Company, it is headed by M. P. Rowe and G. T. Rummell, both of Grand Junction. The vertical shaft is 240 ft. deep. Drifts vary from 5 by 7 ft. to 6 by 8 ft. Holes for blasting are drilled 1⅞ in. in diameter and from 5 to 6 ft. deep, using Ingersoll-Rand and Thor jacklegs. Ingersoll-Rand Model 75H compressors of 375 c.f.m., electrically driven, furnish the compressed air. A

typical drill round comprises a 5-hole burn cut and reliever holes less than a foot from the center holes. The rib holes, usually 17 to 22 to the round, are 15 to 24 in. apart. The holes are loaded with Hercomite® 4-X in 1 by 8-in. cartridges. The charges of dynamite fill the holes to 1½ to 2 ft. of the collar, tamped with a hardwood pole. There is no stemming. Blasts are fired with blasting caps and safety fuse. The lengths of the fuse regulate the order of detonating the charges. Excellent results are obtained and no secondary blasting is necessary.

In stopes and softer formations LaSalle gets satisfactory results by loading the blast holes with Hercomite 5-X in 1 by 17-in. cartridges. After blasting, the broken material is recovered by muckers and slushers and hauled in an Eimco Model 401 tram system which tows Z-20-type Card cars, each side-boarded to 1-ton capacity. The cars dump into a skip pocket. Ore is lifted to a surface bin in a 2-ton skip by a Vulcan hoist. Mill-bound trucks load from the surface bin.

The LaSalle equipment includes two Eimco 12B muckers, three Joy FF211 electric slushers, six Joy S211 and one Ingersoll-Rand air slushers.

Jess Allen is the superintendent of the LaSalle Mine and Pete Walker is the foreman.

In addition to its mine near Uravan, Colorado, the LaSalle company has a smaller operation on the Green River, some 40 miles northwest of Moab, Utah, and quite a few claims in the Plateau region.

Mineral Joe Mine

The operating procedures at the Mineral Joe Mine of Climax Uranium Company on Monogram Mesa near Naturita, Colorado, are similar to those at the LaSalle Mine, but with some differences because of special problems. Climax uses the open-stope method. The shaft, 255 ft. deep, was started in April of 1954 and finished in six weeks. In blasting the ore in the mine, Andy O'Korn, the mine superintendent, uses a 17 to 22-hole drill round, with a 5-hole burn cut in the center. The holes are drilled 6 ft. deep with 1⅝-in. bits. Each hole is loaded with Hercomite 5-X in 1¼ by 8-in. cartridges. The hook-up of the leg wires of the No Vent® Delay Electric Blasting Caps, from 0 through 10 periods of delay, is a straight series connection. Blasts are fired from a permanent blasting switch located near the shaft.

At the Mineral Joe Mine of Climax, the drilling of the blast holes is done with Gardner-Denver S-48 jacklegs and Portland knock-off bits. After blasts are fired, the broken material is hand-trammed to a Hendrie-Bolthoff 50-hp. electric hoist. Electric power is furnished by the San Miguel Valley REA system. Mine equipment includes five Joy 7½-hp. electric slushers, two Eimco 12B mucking machines, two Gardner-Denver S-48 jacklegs, and two 365-c.f.m. Gardner-Denver compressors. Climax is also operating a drift-in mine in this same vicinity.

Cord and Radon Mines

Two big neighbors of the LaSalle and the Mineral Joe Mines in the Big Indian over in Utah some 40 miles south of Moab are the Cord Mine and

NETWORK OF ROADS: The network of roads winds around the hills like a string around a top. Men have dragged drills to places that look perilous for a mountain goat.

the Radon Mine. The Cord Mine is the property of E. L. Cord, one-time auto maker. The Radon Mine is owned by Federal Uranium Corporation and is operated by the Hecla Mining Company. Both use the long wall retreating type of mining but do it differently. Cord has its main haulage below the working drifts and will mine from 30 to 70-ft. raises 175 ft. apart. In the Radon Mine, the main haulage will be on the working level. Both properties were in production in July, 1956, mainly from scram drifts and other development.

The shaft at the Cord Mine is 625 ft. deep; the Radon Mine shaft is 690 ft. deep. Cord plans to use metal stulls in its retreating operation. A definite pattern for blasting the ore had not been determined in these two major mines. Although the rock in these mines is not extremely hard, it is a tough formation and somewhat difficult to pull.

George Teal is general manager of the Cord Mine, and Phil Lindstrom is manager of the Radon Mine.

Included among the principal operators in the Big Indian-Lisbon Valley area are Utex Exploration Company; Standard Uranium; La Sal Mining and Development Company (subsidiary of Homestake Mining Company); Cord; Continental Uranium (owner of the open-pit development called The Rattlesnake); Hidden Splendor; Hecla; Lisbon Uranium; and Cal Uranium. One place in the district is known as the Ike and Nixon; here, Lisbon Uranium has named its workings the Ike Shaft.

The Fabulous Steen and Pick Properties

Of course, Utex Exploration Company (named for Utah and Texas), one of the more famous and productive operations on the Plateau, is in the Big Indian. This mining development had its beginning with the discovery of Charles Steen, the Texas geologist who almost starved himself and his family through four years of prospecting before he struck it rich. Steen's discovery added zest to the uranium boom, for it was bonafide proof that a persistent prospector could hit something worth millions. Tourists are still eager to see the spot where Steen drilled a 71-ft. prospect hole with a broken-down drill and tapped his orebody. They also stop in the little town of Cisco and ask about the shack in which the Steens were living when the core from the famous drill hole made a service station Geiger dance.

Instead of accepting enormous offers for his holdings, Steen decided to develop, to mine, and to mill. His big drift-in mine is operated from two portals. The mill just outside Moab is well under construction. Steen is one of the really big uranium operators.

Another famous and widely publicized discovery is Vernon Pick's Delta Mine on Muddy River 75 miles southwest of Green River, Utah. It is now being operated by Hidden Splendor.

Kerr-McGee Operations

Some of the smaller and less-publicized mines are as genuinely interesting as the bigger ones. Among them are the operations of Kerr-McGee Oil Industries, Inc., in New Mexico and Arizona. Long recognized as a pro-

IN MESA NO. 3 MINE: One of the Navajos uses a Copco jackleg to drill a round of holes for blasting in the ore in Kerr-McGee's Mesa No. 3 Mine.

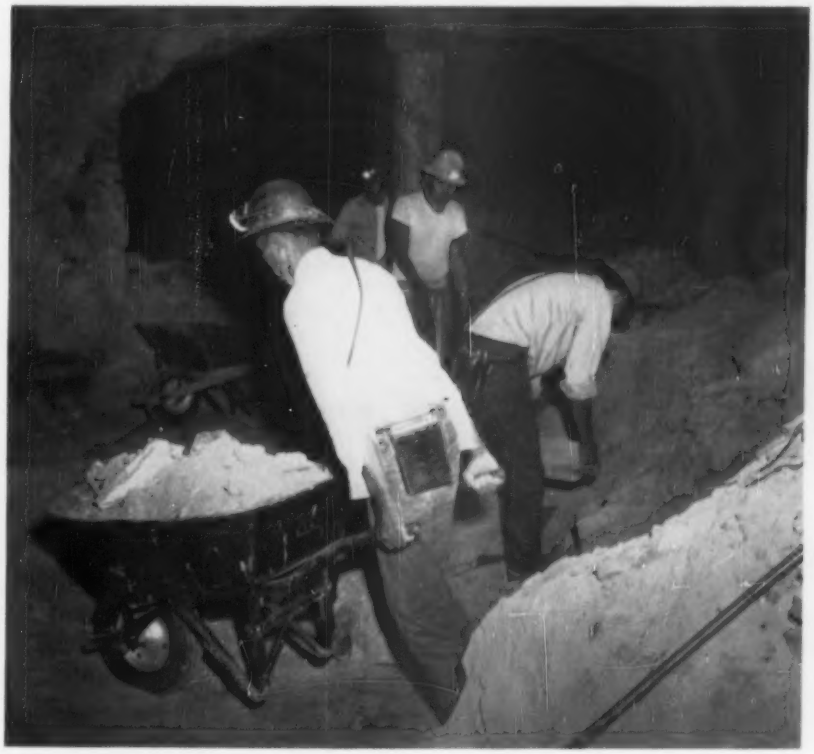
gressive, growing concern in the petroleum industry, Kerr-McGee (Robert S. Kerr, U. S. Senator from Oklahoma, and Dean A. McGee) branched into uranium in 1952 when it bought the properties and assets of Navajo Uranium Company. Since that time, Kerr-McGee has become one of the major uranium operators, with mines in the Lukachukais, a tremendous development project and orebody at Ambrosia Lake, just north of Grants, New Mexico, and a $4,000,000 mill just outside Shiprock. This company, the first oil-business concern to construct a uranium mill, has been a pioneer in mining and metallurgy. Within a year it may very well be one of the nation's biggest operators.

Only recently Kerr-McGee joined with the Pacific Uranium Mines Company of Los Angeles and the Anderson Development Corporation of Albuquerque in forming the Kermac Nuclear Fuels Corporation to mine and mill ore at Ambrosia Lake. The new company will operate on holdings of the three companies within 25 miles of the currently proved orebodies. Kerr-McGee holds the majority interest and will staff and operate the new corporation, with Dean A. McGee as president.

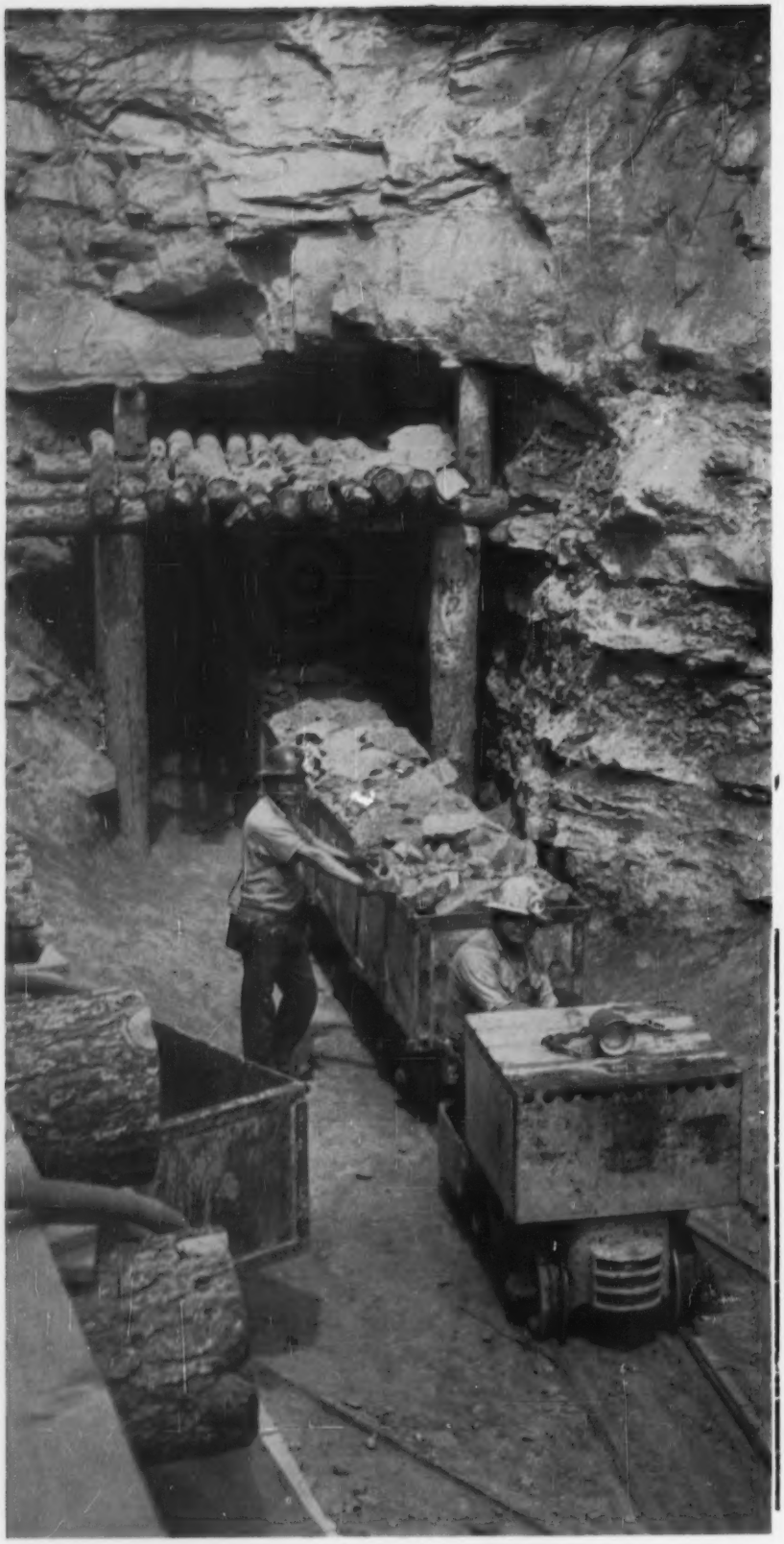
Development is moving rapidly in the uranium-rich Ambrosia Lake area. Meanwhile, Kerr-McGee is taking ore from three of its own mines and has five contracts for additional ore with operators high in the Lukachukais at an elevation of 8,000 ft. Nearly all of the production from the company-owned mines is carnotite-roscolite ore from what is known as the Salt Wash of the Morrison formation. It often contains petrified trees and the remains of king-sized lizards that cavorted in the region long before the invention of the bow and arrow. Not long ago a dinosaur the size of a tandem ore truck was found in Kerr-McGee's Mesa No. 3 Mine. Marion Bolton, the manager of mines, saved one hunk of its backbone for display in his office.

The Mesa No. 3 Mine is a good example of mining in this remote country, 50 crooked miles from the Shiprock mill. It is a drift-in operation with a weird pattern of rooms. The miners really follow the ore – up and down,

RECOVERING BLASTED ORE: After a blast, the broken ore is recovered and loaded out with an Eimco mucking machine into 1-ton Card cars.



PILLAR ROBBING: As new raises are driven in Mesa No. 3 Mine, old rooms are worked out and their pillars pulled on the retreat.



EN ROUTE TO THE BIN: Cars loaded with blasted ore are towed out of Mesa No. 3 Mine to the bin on the portal level by a Mancha electric trammer.

on slant, and in bends. Quite a few big ore pockets have been found in mining that had not been detected by prospect drilling from the surface. Likewise, there are some pinch-outs that were not found in the core drilling. Most of the ore is recognizable with the eye, but counters and assays help guide the miners. As new raises are driven, old rooms are worked out and their pillars pulled in the retreat.

Drilling and Blasting

In the drifts and raises, the 1⅞-in.-diameter blast holes are drilled 6 ft. deep. The holes average 20 to the round, spaced on approximately 12-in. centers. They are loaded with a 30% semigelatin dynamite in 1 by 8-in. cartridges and fired with blasting caps and safety fuse. Primary blasting is effective – the maximum size of the ore that the mill can handle is 12 in., and few break larger than that.

Holes for blasting are drilled with Copco jacklegs, Copco steel, and tungsten carbide chisel bits. Compressed air is delivered to the drills from an Ingersoll-Rand GyroFlo 600-c.f.m. compressor. The mine is equipped with an Eimco Model 12B mucking machine, and trains of loaded cars, six 1-ton Cards of 20-cu. ft. capacity, are moved out of the mine by a Mancha electric trammer and charger. Mine transportation includes a Dodge Powerwagon and Willys Jeeps, all 4-wheel drive.

For prospect drilling, Kerr-McGee uses Mayhew 1500 rotary core drills, truck mounted, each with an Ingersoll-Rand 600-c.f.m. compressor. The drills use Tricone bits that bore a hole 4¾ in. in diameter. When the company first began operations in the region, a 50-ft. prospect hole was considered almost China deep. Now it isn't unusual to drill to a depth of 500 ft. In a general way, an orebody can be blocked out with this drilling.

Ore from the Mesa No. 3 Mine is dumped into a bin on the level of the portal. Fourteen-ton tandem trucks load from the bin and start the long, grinding pull up, down, around, and over hills and canyons to the mill at Shiprock. Ore hauling is by contract on a per ton basis.

Nearly all of the uranium mines in the district, including one owned by Climax Uranium, are operated in the

Uranium

AND ITS COUNTRY

AN ESSAY IN WORDS AND PICTURES

Born out of grim necessity
In the horror and agony of Hiroshima, Nagasaki,
The Nuclear Age grew from swaddling clothes
Into manhood almost overnight.
There was a question mark over the future
From the first hour the birth was announced.
Today, eleven years have passed
Since that first blinding flash of light
Wrote upon the pages of history
Another chapter in Man's conquest of nature.
There is still a question mark.
It is still not certain
That Man's conquest of himself is complete.
The awesome power of the creation
Is in truth linked to Man's good intentions
And his striving toward improvement of his lot.
There is still the question mark—
One misstep and then destruction.
There is, however, hope and faith
That only good and no evil
Will emerge from the nuclear piles
That begin life in the colorful, barren earth
Of New Mexico, Arizona, and Montana,
Of Utah, Colorado, and Nevada.
There is an omen for good in the lilt of the names
Given to places only yesterday known but to a few.
Listen to the singing of Monument Valley,
Moab, Red Rock, and Monogram Mesa.
There is Mexican Hat, and Paradox Valley,
Shiprock, Cisco, and Naturita.
Then, there's Dead Horse Point.
Oh, yes, this is Indian Country,
Home of the Navajo!
They are still the only masters
Of this desolate waste
Which reflects the colors of uranium
In both its raw and finished state.
The yellows and greens of ore are there;
The flaming red of fire is there.
Only the most rugged life,
Both animal and vegetable,
Manages to survive,
And it has been so for centuries.

The early Indians used uranium
For their war paints,
Unaware of any portent for the future.
And the skeleton of a giant dinosaur,
A fossil of an early chapter in history,
Was tumbled out of the rock
With its ancient bones so radioactive
A Geiger counter came to life.
Life! That word keeps recurring.
Uranium can mean much to life and to living,
If the power Man holds in his hands
Is devoted to the glory of a future at peace.

It's a lonely business for the prospector, seen here in the desolate uranium country staking out his claim according to the manner required by law.

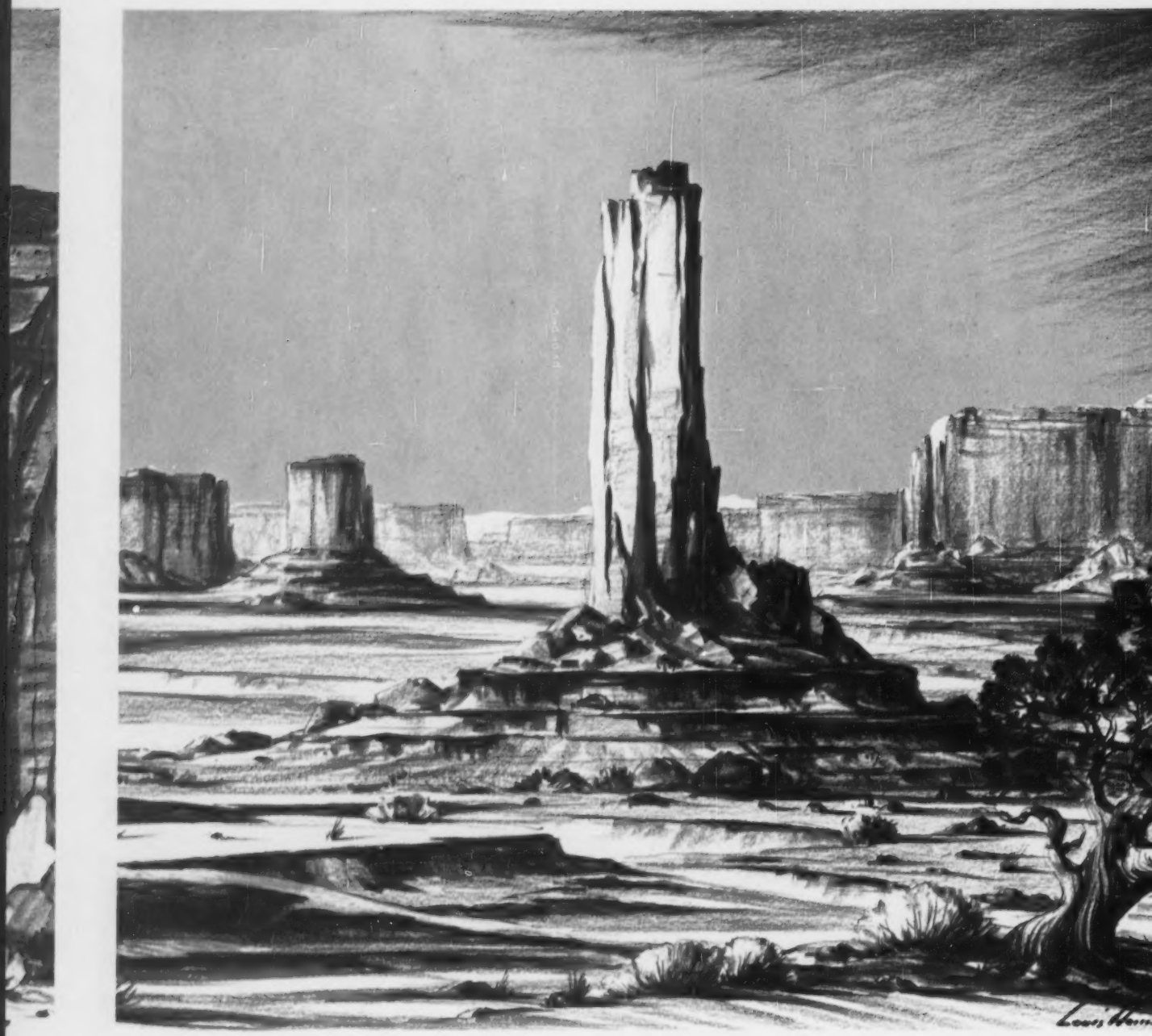
Cliffs of flame-red sandstone drop with rhythmic grace into the depths of the earth where the Colorado and Green Rivers continue to erode a path toward the sea. This is Dead Horse Point, site of many uranium mines. With its endless layer cake of geologic formations, it is a priceless chart for geologists. Beyond the desolation, snow-capped peaks of the LaSalle Mountains reach upward more than 13,000 ft.

DRAWINGS BY LOUIS HEINZMAN

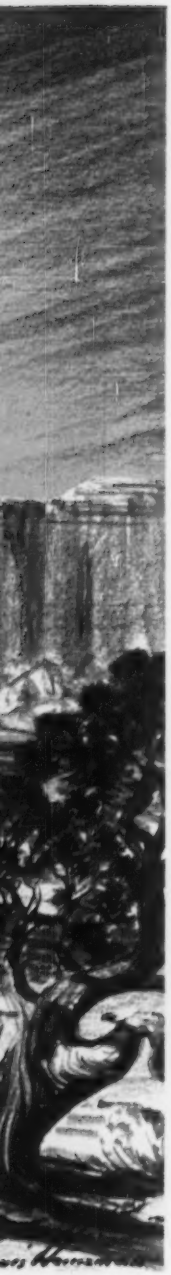
TEXT BY ASHWORTH BURSLEM

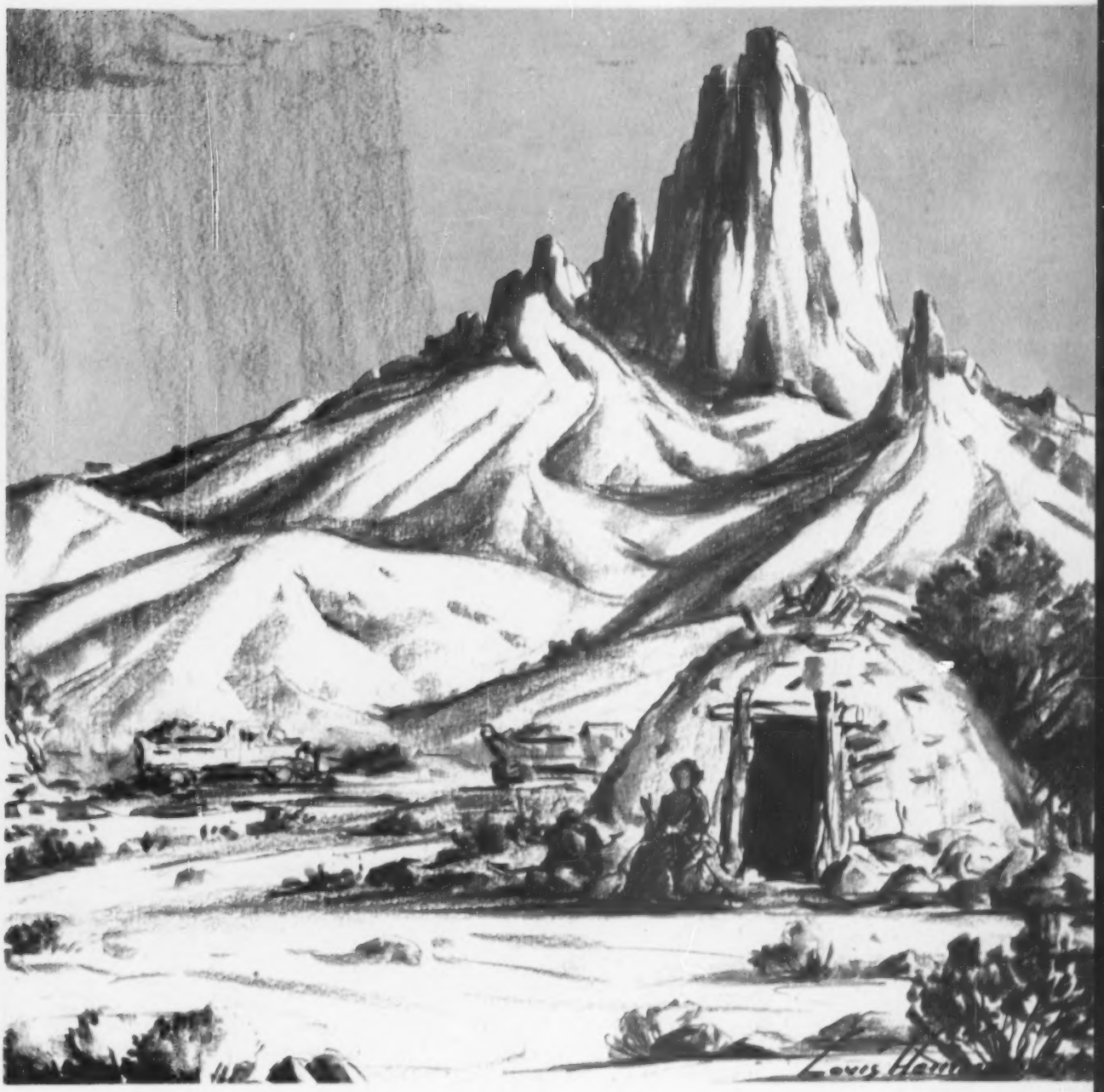
This is Indian Country, home of the Navajo, first users of uranium for red and yellow war paint and their sacred sand paintings. Today, many are expert prospectors for the elusive ore even without the help of modern devices such as Geiger counters or scintillometers.

The ancient past and the most modern devices are linked here at Mexican Hat. Aerial prospecting by helicopter, calling for consummate skill and nerves of steel, makes remote areas with deposits of uranium ore quickly accessible.



There was a time when Monument Valley's only claim to fame was as the most remote place from any railroad in the United States. Now a focal point in the feverish search for uranium, the massive red sandstone, cast in weird and unusual formations, leaves no doubt as to the origin of its name.





Some of the Navajo Indians, living unchanged in their hogans and tending flocks of sheep and goats, pay no heed to the ponderous trucks laden with uranium ore and supplies as they rumble across the desert floor.

It is fitting that near Moab, Utah — a name of Old Testament heritage — should be found the Great Organ rising hundreds of feet from the floor of an outdoor cathedral known, with seeming lack of dignity, as Courthouse Wash.

The old and the new side by side provide sharp contrast at Moab, which might be called the capital of the uranium boom on the Colorado Plateau. Once a sleepy Mormon town of 1,000 persons in a verdant valley engulfed by towering red sandstone cliffs, Moab today is the home of more than 6,000 people.

way outlined here, although each has its own problems. Compared to large mines elsewhere, and to old, established ones, the operations look a bit primitive – along the line of mole-hole operations. But, it is bringing out the uranium from a spectacularly wild and beautiful country that was almost a forbidden land until it billowed up like a mushroom with the advent of the atomic age.

The network of roads in the Lukachukais looks as if a thousand or so miles of vapor trails from assorted jet planes had settled haphazardly in the hills and melted out paths. The dim outlines of drill roads zigzag every which way; men have dragged drills to places that look perilous for a mountain goat. The access and haulage roads represent one of the world's most tremendous jobs of bulldozing. They wind around hills like a string around a top. Caterpillar D-8 and D-7 dozers were used by Kerr-McGee for this very necessary work.

The Navajos

The mining out there looks primitive, and it really is. Nearly all of the work in the Kerr-McGee mines is done by Navajos, under the supervision of white foremen. At the Climax company's mine, even the foremen are Indians whose ancestors used a little uranium from outcroppings to mix in body paints.

The Navajo Indians are among the world's most primitive people. For centuries they have existed in a tough, unproductive land, living one day at a time and never worrying about tomorrow. To a great extent, many of them – meek, timid, and superstitious – live just as they have for a thousand years. The flashing flight of a hurried civilization overhead, the streaks of it along the rail lines, and the tourist wide-eyed for the wild and woolly, have made little impression on the Navajos in their dark hogans, with the

UTEX MINE – SURFACE STRUCTURES: Aerial view of the camp and surface structures at Utex Mine in the Big Indian, one of the top-production operations on the Plateau.

AT AMBROSIA LAKE: Prospect drilling and ore-outlining activities by Kerr-McGee forces at Ambrosia Lake near Grants, New Mexico.

doors always in the due east and the smoke holes in the very top centers.

You have to hand it to the Navajos for being able to exist in this desolate land and applaud them for increasing their numbers.

Some of the things they do look foolish to the average paleface. There's not much available water on the reservation, but the Navajos do not seem to mind; they do not build their shacks near water but tote or haul what little they use. There is not enough water in the vicinity of the average hogan for things like washing hands, let alone baths. Many a middle-aged Navajo has never had a bath. This fact can be detected in close quarters, especially in the spring when the sheep fat they rub on their bodies for warmth in the winter begins to melt off.

One deeply set superstition worries mining men – the Navajos will not touch a dead body or tarry long where one has been. When one of the tribe dies in a hogan, all the others there gather their belongings, move out, seal the door, and leave the corpse exactly where the last breath was drawn. A hole is made in the west side of the hogan to let out evil spirits. In mining work in the area, quite a few old hogans have been knocked over. Invariably there is a skeleton in the deserted dwelling.

Mine operators have been fearful that an Indian may die in a mine; they don't know whether they could ever get another Navajo into the works. One company had a family of Indians living in a shack. There was a death and the Navajos hit the trail, leaving the body. A little later, the company sold the shack to another concern that moved it to its camp as an Indian dwelling. When the proposed new occupants approached the shack, they stopped, turned, and hurried away. Somehow they recognized the shack as a place where an Indian had died.

The Navajos look a great deal like Orientals; they are convincing visual proof that the Indians came from Asia in the long ago. However, they have their own beliefs about their origin. Some believe their people came creeping from under certain ledges in the LaPlata Mountains and that their ancestors were bears, wolves, and fish. This protects the bears, wolves, and fish from the Navajo's dish. Another belief – restricted largely to the Shiprock area – is that they arrived in New Mexico by ship from the Northland, thereby escaping the wrath of warring enemies. The ship turned to the rock from which Shiprock gets its name; it stands some 1,750 ft. high and can be seen for many miles. It resembles an old square-rigger. As paleface geologists see it, the rock is a volcanic plug. It fractured the earth's crust eons ago

and the cracks filled with escaping lava, forming one of the most perfect geological dikes.

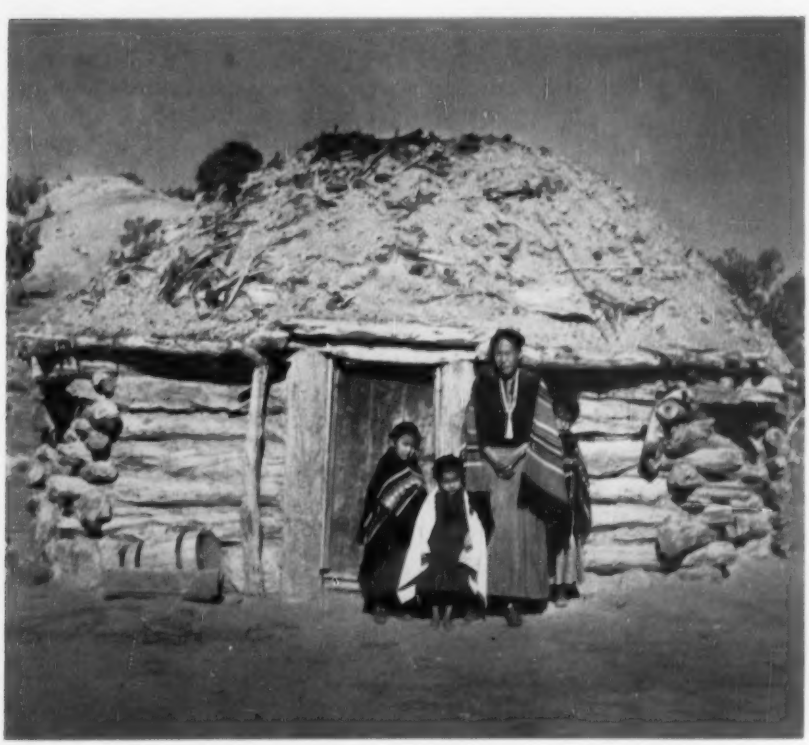
Few Navajos can speak English and those who can won't talk to strangers. Despite all the drawbacks, the Navajos are doing a good job of mining uranium; in many cases they have become experts at drilling blast holes and handling explosives.

Marion Bolton, an Oklahoman, the mine manager for Kerr-McGee in the Shiprock area, has done wonders with the Navajo miners. With great patience, he has treated them with understanding, taught them how to work in the mines, and gained their full confidence. The Navajo mill men like the showers in the change room; several of them travel to the plant on their day off just to take showers. This tends to prove that it has been water shortage, and not desire, that has kept the Indians among the great unwashed.

The Mill at Shiprock

Kerr-McGee's mill has made a prosperous, attractive town of Shiprock which not too long ago depended on the old volcano plug as the chief attraction. The company has built comfortable housing units and brought in many families.

FAMILIAR SIGHT: It is not unusual to see a Navajo workman riding his horse to the mines in the Shiprock area. Atomic energy boomed out a new day for the Navajos.



NAVAJOS: A Navajo mother and her children pose in front of their hogan with the door to the east and the smoke hole in the top center.

The mill, the seventh erected on the Plateau, runs 24 hours a day. The company's mining properties and those of its contractors do not produce sufficient ore to keep the mill busy. So Kerr-McGee buys ore from other mines. On the stock lots one day last June an observer could see good examples of ore from all over the Plateau.

When a truck loaded with ore rolls up to the mill, it is weighed, a sample taken, and the contents dumped on what is called a stock lot. Kerr-McGee buys ore on the basis of uranium content. When the stock lot of one deliverer, or seller, amounts to 150 to 200 tons, the ore is run through the sampling mill for a determination of the uranium value and then usually hauled to the stockpile to await milling, or else it goes directly into the mill.

Like mining, metallurgy has posed problems in this new industry. Up until the advent of the atomic age very little uranium had been recovered. The uranium content of Plateau ores, mainly vanadium, had gone to tailings.

SAMPLING PLANT: This area includes the Kerr-McGee ore-sampling plant at Shiprock and conveyors that lead into the mill.

It was from these old tailings ponds that the uranium for the first atomic bombs was taken. Since that time, metallurgists have labored in mill and laboratory on effective, economical methods of recovering uranium.

Processing Methods

The Shiprock plant has been a sort of pioneer. Placed in operation on November 1, 1954, it is now using its third method of processing U_3O_8. At first it made use of the "acid cure." Developed by private enterprise and the AEC, it was considered the very latest process. The Shiprock plant was the first to use it.

Later, a direct leaching process was adopted. In July, the plant was being equipped for the third method, the continuous solvent extraction. Unexpected developments in a new industry as well as the advance of metallurgy led to the changes at Shiprock.

The plant was designed originally to treat ores from the Lukachukais. These ores were relatively low in lime content and fairly high in vanadium and the mill was designed to extract both uranium and vanadium.

As the plant neared completion there were two developments: first, the quantity of ore available from the Lukachukais fell below original estimates; second, the market for vanadium deteriorated to a point where the AEC was not concerned with its recovery. As a result, the Shiprock plant found it necessary to treat ores from areas containing small amounts of vanadium and fairly high concentrations of lime. The AEC then modified the contract to eliminate the production of vanadium.

With the original process, after the ore was sampled, crushed, and drawn from blending bins it was conveyed to a mixer, or pug mill. In the pug, the ore was mixed with 10 per cent water and about 425 lb. of concentrated sulphuric acid per ton of dry ore. After thorough mixing, this mass of ore and acid was transported in a front-end loader to a patio where it was dumped in a pile for curing. In this curing, the vanadium and uranium minerals were decomposed into water-soluble salts. After about six hours, the mass was again picked up in a front-end loader, charged into a leaching system, and violently agitated for one hour with additional sulphuric acid. After leaching, the remaining insoluble portion of the ore was separated into a slime fraction and a sand fraction. The slimes were washed in a series of thickeners and the sands were washed in spiral classifiers. An interlocked countercurrent washing system was used between the thickeners and the classifiers.

The dewatered solids were delivered to tailings and the clear liquor overflowing the No. 1 thickener constituted the pregnant liquor containing the uranium and vanadium values. This liquor, after pH adjustment with ammonia, was fed to the ion-exchange columns. In this process, the uranium was extracted from the sulphate solution and deposited on the "sites" of the ion-exchange resins. The barren liquor, after leaving its uranium content on the resins, was pumped into vanadium liquor storage ponds. It was expected that the vanadium would be recovered at a later date when market conditions improved.

This has happened, and in July the plant was being readied for vanadium extraction.

After the resins became loaded with uranium, the feed was switched to another column and the loaded column

was eluted with brine and hydrochloric acid. This elution process removed the uranium from the resin and returned it to its original condition, ready to be treated with more "preg" solution.

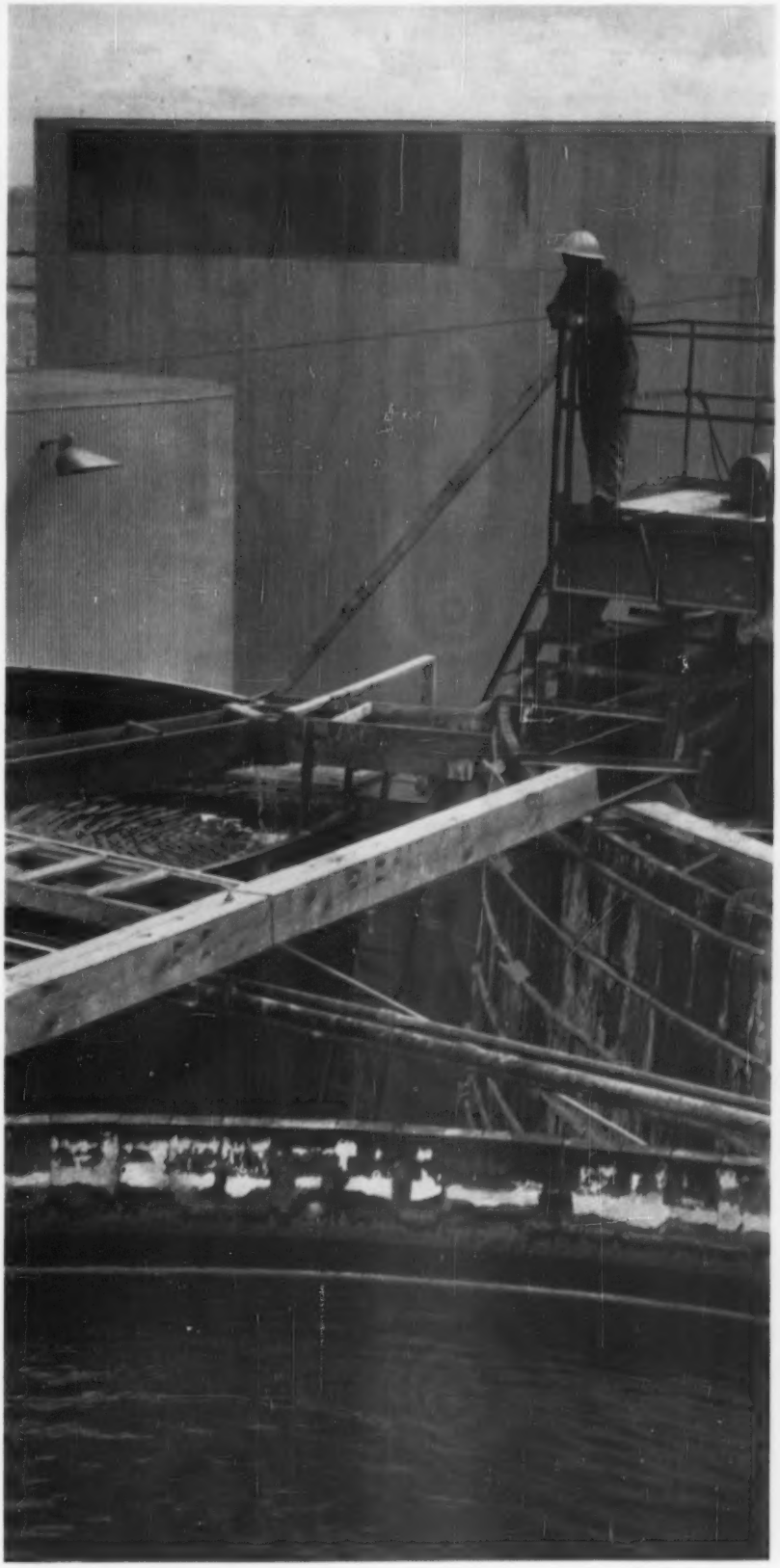
The eluate from this process was then treated with ammonia, which precipitated the uranium as yellow cake.

In the second process adapted by the mill, the crushing and grinding were essentially the same as those in the original method, which has been eliminated. In the second process the solubilization of the uranium was accomplished by taking the ore from the blending bins into a series of leaching agitators where it was mixed with sulphuric acid for 16 hours. This direct leaching method consumed less than one-half as much acid as the cure process. There was also a marked reduction in both labor and equipment requirements. Moreover, the direct leach was more efficient in dissolving the uranium values, but dissolved only about one-half of the vanadium. As before, the flow continued to the ion-exchange unit. However, this was augmented by a small batch solvent extraction unit, which treated about 50,000 gallons of pregnant liquor daily.

Work in progress will add two important features to the plant: first, a vanadium-recovery unit was being installed to produce a so-called "brown cake" containing about 65 per cent V_2O_5 (vanadium pentoxide). Vanadium will be recovered from liquors currently produced as well as from the vanadium ponds which were filled during the earlier operation. Second, a continuous solvent-extraction unit was being installed. This unit will have a capacity about equal to that of the ion-exchange unit.

Solvent-Extraction Process

The feed to the solvent-extraction unit will be the same as that to the ion-exchange. The process includes a solvent prepared by mixing two organic phosphate compounds and dissolving them in kerosene. This solution is then violently mixed with the "preg" liquor containing the dissolved uranium. In this operation, the uranium is transferred from the aqueous sulphate solution into the organic phase. The mixture of organic and aqueous



THICKENERS AND TANKS: Here is a look at some of the thickeners and solution-holding tanks, with the agitator building in the background.

liquids is then transferred to a settling tank. There the pregnant organic liquid collects on top of the barren aqueous solution. The barren solution is pumped to tailings and the pregnant organic solution is stripped of its uranium values by agitating with soda ash. The stripped organic is returned to the head of the circuit to meet more pregnant solution and the operation is repeated.

The pregnant carbonate solution obtained by stripping the organic is then precipitated with caustic soda. This precipitate is filtered, dried, and packed in drums for shipment to the AEC.

The Shiprock plant was the first in the nation to use the solvent-extraction method. During the past summer, Climax Uranium was converting its Grand Junction mill to this system.

The Grants Area

This does not mean that the solvent-extraction method is *the* way. Plants have to be adapted to the ores they process. For example, the plant Kerr-McGee has designed for the big operation at Ambrosia Lake will not use solvent extraction but a carbonate leach process in which the uranium will be dissolved with sodium carbonate. At the beginning, at least, this plant will produce yellow cake. Later, it may go another step and turn out green salts.

The Kerr-McGee plant at Ambrosia Lake will be about six times as large as the Shiprock plant, with six times the capacity.

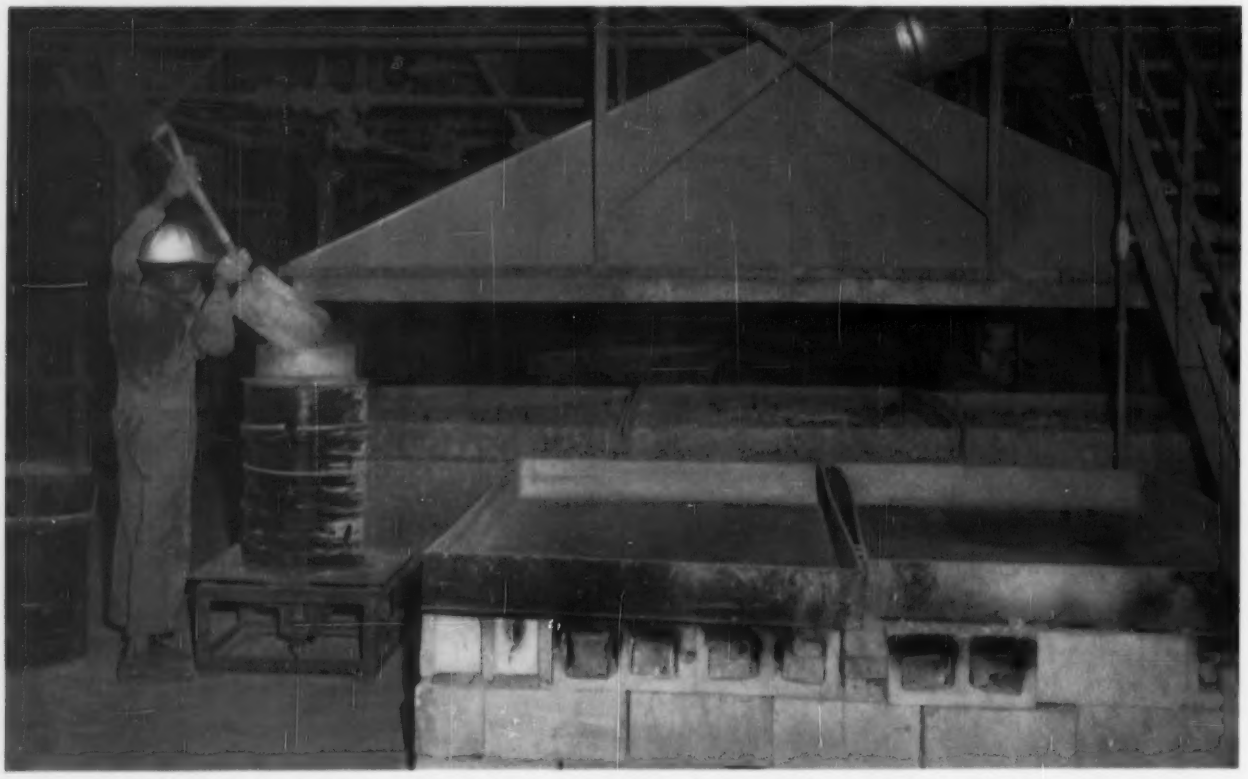
Last July, the new plant was on the drawing board and plans were on tap for the sinking of two shafts approximately 800 ft. deep. The tremendous orebody — carbonaceous sandstone mineral — was being blocked out by core drilling. Thirty rigs were busy with the drilling which called for at least 1,000 holes. Mining methods for this operation had not been worked out completely, but the coffinite was the system under main consideration.

It is beginning to look as if the Grants area may become the biggest in uranium operations. Paddy Martinez, a Navajo, made the original discovery on Haystack Butte north of Grants in the summer of 1950. If you were to tell Paddy that his find led to the initial uranium discovery in the Todilto limestone of the Lower Jurassic Age, he probably wouldn't know what you were talking about. But, that's what Paddy did. The discovery was on Sante Fe Railroad land. Anaconda Copper Mining Company of New Mexico moved in with exploration, operated a buying station, and, later, constructed a plant which serves some 30 to 50 producers.

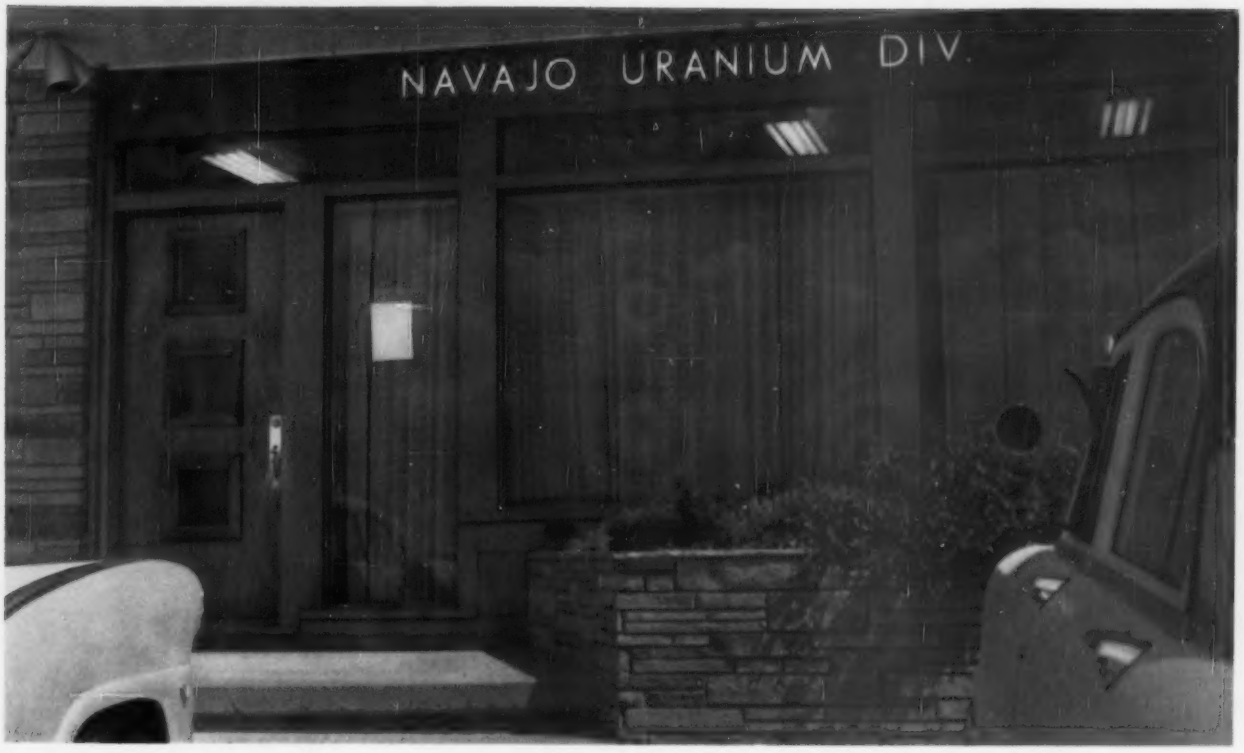
A little later, uranium was found in sandstone higher in the geologic column than the Todilto. This led to the development of Anaconda's big producer, the Jack Pile Mine.

Grants hasn't had the publicity of Moab, Grand Junction, and other places associated with the uranium industry. But, extensive exploration continued there, and, in this way, the giant orebody of Kerr-McGee was found. The reserve there is classified information and cannot be released, but it is tremendous.

The Grants operation (Ambrosia Lake) bears out the wisdom of the Kerr-McGee management to branch out into uranium. The company began business as an oil well-drilling outfit and expanded into nearly all the



YELLOW CAKE: A Navajo shovels yellow cake into a drum at Shiprock for later shipment to the Atomic Energy Commission.



SPIC AND SPAN: This attractive office entrance of the Navajo Uranium Division of Kerr-McGee Oil Industries, Inc., is typical of the company's good-housekeeping policies. The first oil-business concern to build a uranium mill, Kerr-McGee has pioneered in mining and metallurgy.

phases of the petroleum industry. U. S. Senator Kerr, who has to devote much of his time to political service, is chairman of the board. Dean McGee, the aggressive No. 1 man in all operations, is the company president.

About a year ago, Vernon L. Mattson became associated with Kerr-McGee as manager of mines and ore processing. For a long time he was director of the Research Foundation of the Colorado School of Mines at Golden, Colorado. From there he went to Kerr-McGee. Most of his time is devoted to mining and ore-dressing operations and problems, including a planned potash development at Carlsbad, New Mexico. The potash project will be operated in conjunction with Phillips Petroleum and the National Farmers Union.

The headquarters and main office personnel of Kerr-McGee are in Oklahoma City, Oklahoma. A. T. F. Seale is vice president in charge of manufacturing and heads Kerr-McGee's uranium mining and milling activities. With offices in Denver, V. L. Mattson directs mining, milling, and research; and John Masters heads the exploration program. Wayne Hazen is manager of the Denver research laboratory.

As indicated previously, Marion Bolton is mine manager in the Shiprock area and also assists with mining problems at the Ambrosia Lake operations. Gene Meyer, manager of the Shiprock plant, was a former associate of Mr. Mattson at the Research Foundation of the Colorado School of Mines. Vernon Wildon is mine foreman, and George Snyder is office manager at Shiprock.

George H. Cobb will be vice president and manager of operations for the newly formed Kermac Nuclear Fuels Corporation at Ambrosia Lake.

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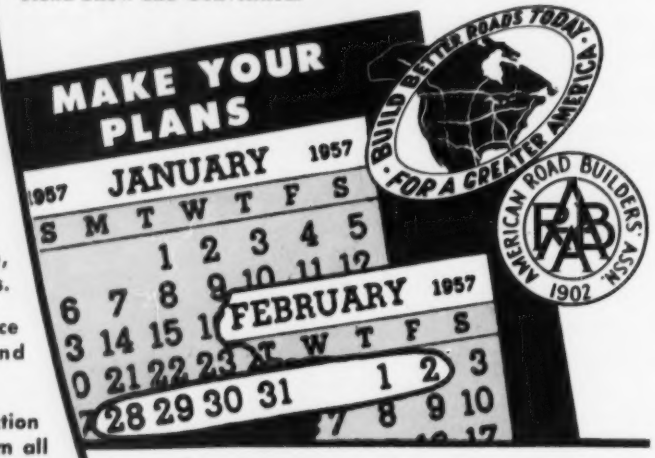
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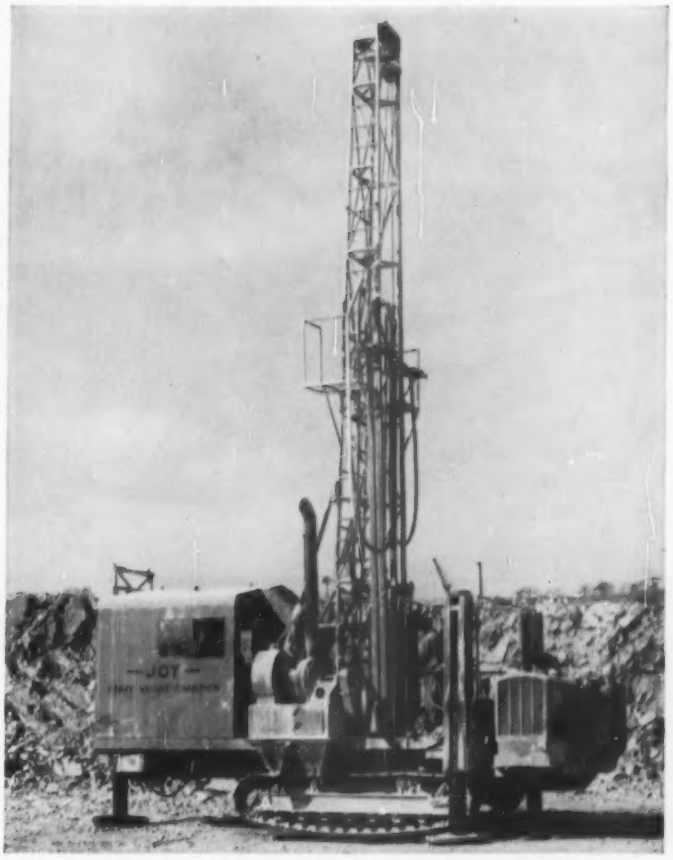

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PIONEER AND WORLD'S LARGEST MANUFACTURER OF ROTARY BLAST HOLE DRILLS

Run one end of the Quarrycord out to a place where it can be lighted easily. When everything is in readiness, light the Quarrycord with a match and walk away.

Quarrycord

for one-shot lighting of safety fuse in secondary blasting

(PLEASE GIVE THIS ADVERTISEMENT TO YOUR BLASTING FOREMAN)

Now you can ignite each and every safety fuse from *one point*, and eliminate the hazard of men climbing over the rock pile, lighting each fuse individually.

Now you can have the advantage of fuse blasting, so that the holes go "pop-pop-pop" rather than "BOOM" — to reduce the noise of a single blast.

Now you can fire when convenient, without fear of stray electrical currents causing premature blasts.

Quarrycord is a flexible, water-resistant cord which burns with an external flame at the rate of about one foot per second.

It is very easy to use: (1) Prepare each primer cartridge in the usual way with safety fuse and detonating cap. (2) On the end of the fuse opposite the cap place a Quarrycord Connector. (3) Load and tamp the holes. (4) When ready to blast, run a line of Quarrycord so as to connect with each hole (5) At each fuse, pass the Quarrycord into the slot in the end of the connector and press the "lid" down *tight* over it to make positive contact. (6) If your hook-up has parallel lines of Quarrycord, make frequent cross connections as shown.

Quarrycord is packed on spools in 500 foot lengths, two spools to a box. Connectors are supplied in cardboard boxes containing 100 each.

For more information
see your Explosives Supplier, or write to

THE ENSIGN-BICKFORD COMPANY
Simsbury, Connecticut

Manufacturers of Primacord® Detonating Fuse, Safety Fuse, Ignitacord®, Blasting Accessories.

Established 1836

Free Folder tells the whole story: what it does, and how to use it. Every Blaster should have a copy — send for it today.

ENSIGN-BICKFORD

Quarrycord

for lighting Safety Fuse in Secondary Blasting

Q-4

ACROSS HILLS AND VALLEYS

Explosives Research Pays Off

Blasting trenches in hard granite formations to install a pipeline in Southern California called for engineering skill, operating know-how, and a knowledge of explosives.

Over hills and valleys and across rivers and gorges, pipelines provide safe, sure, economical means of transportation for petroleum, natural gas, water, and other mineral resources. When rock is encountered, blasting crews with specialized explosives take over. Here is where explosives research pays off.

Continuous research and extensive knowledge of field conditions have been Hercules' business for more than forty years. Hercules technical representatives welcome opportunities to discuss problems and help in the selection of the right explosives and the most efficient methods for use in mining, quarrying, construction, and exploration projects.

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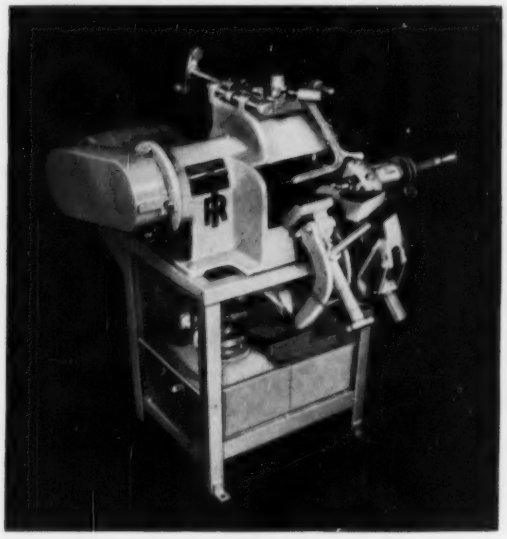
XR55-3

CARSET JACKBITS

LAST LONGER, DRILL FASTER THAN EVER

...when you keep them sharpened, with machine precision, on the new

JC-3 JACKBIT GRINDER



A NEW Ingersoll-Rand Carset Jackbit has no equal for sustained high drilling speed and maximum bit life in practically any type of rock.

To maintain this "good as new" performance after resharpening, it's important that the cutting faces be ground without unnecessary waste and to the proper shape. Although hand grinding can be used successfully where the number of bits sharpened per day is limited, higher production calls for a *faster* and *more precise* method of resharpening.

These requirements are met to excellent advantage with the new JC-3 Jackbit Grinder. All bit surfaces are ground with machine precision to exactly the right shape for maximum drilling efficiency — more quickly, easily and accurately than can be done by hand grinding.

While the JC Grinder has many new and improved features, it has the same basic design that has proved itself in over 20 years of service. All bearing and wearing surfaces are protected against the entrance of abrasive grits, virtually eliminating bearing maintenance costs. The Jackbit Grinder can be purchased complete with cooling and gauging equipment and electric, air-motor or gasoline-engine drive — or it can be obtained with only that equipment needed for any particular job. To get the *most* out of your Carset Jackbits, ask your I-R representative for complete information on this time-saving, cost-saving Jackbit Grinder.

15-416

FREE WALL CHART: HOW TO GRIND CARSET JACKBITS

Ingersoll-Rand, Rock Drill Dept., 11 Broadway, New York 4

Please send me illustrated wall chart, Form 4121, showing step-by-step instructions for the proper resharpening of Carset Jackbits.

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